AMERICAN JOURNALS
Open Access, Peer Reviewed Journals
American Journal of Technology and Applied Sciences
ISSN (E): 2832-1766 Volume 35, April - 2025

PERFORMANCE INDICATORS AND CLASSIFICATION OF DUST CLEANING DEVICES

K. Yu. Abdullaev
Samarkand State University of Architecture and Civil Engineering

N. U. Toshmatov
Jizzakh Polytechnic Institute

Sh. P.Mansurova
Jizzakh Polytechnic Institute

A B S T R A C T

In this article, for a more accurate assessment of the operation of various dust collectors, when assessing the performance of dust cleaning devices, the area and size of industrial buildings where enterprises are located are taken into account. Dust collectors are designed to clean ventilation (aspiration) waste into the atmosphere if the dust concentration in this waste exceeds the permissible sanitary standards.

K E Y W O R D S

Single-stage air purification, dust cleaning devices, purification coefficient.

Introduction

Compliance with sanitary, hygienic, technological and other requirements for dust-generating production can be ensured by the effective operation of dust-cleaning devices. It is most rational to have a technology that would eliminate dust formation. But at the current stage of development of science and technology, all work in this direction is focused on improving the technological systems for obtaining and processing raw materials, equipment for processing these raw materials, devices for capturing dust, removing it from raw materials, semi-finished products, finished products, air from the surfaces of equipment, tools, special clothing. Dedusting methods and techniques are extremely - diverse.

Experimental research. The following indicators characterizing the efficiency of their operation are common to all types of air dust cleaning devices.

1. The degree of purification of air passed through a dust cleaning device (purification coefficient) is the ratio of the mass of dust retained by the dust cleaning device to the mass of all dust entering the cleaning device.

With single-stage air purification, the degree of purification, %.,

$$\eta = \frac{G_1 - G_2}{G_1}$$

where G_1 is the mass of dust entering the dust cleaning device with air, g; G_2 is the mass of dust leaving the dust cleaning device with air, g,
or

$$\eta = \frac{C_1 - C_2}{C_1} 100\%$$

where C_1 and C_2 are the dust content in the air before and after cleaning, mg/m^3.
The comparative efficiency of dust cleaning devices is determined by the amount of dust passed through, i.e. by the value of 100– η. If the dust cleaning device at the beginning of operation $\eta_1 = 90\%$ and after improvement, adjustment or in the established mode $\eta_2 = 95\%$, then the efficiency of this device has increased by 5%.
If single-stage air purification is insufficient, two-stage purification is used. In this case, the degree (coefficient) of purification

$$\eta_{1\text{-}2} = \eta_1 + \eta_2 - \eta_1 \eta_2$$

where η_1 and η_2 are the degrees of purification of the 1st and 2nd stages.
With multi-stage cleaning, the overall degree of cleaning

$$\eta_{total} = 1 - (1 - \eta_1)(1 - \eta_2)\ldots(1 - \eta_n)$$

where η_1 η_1, ..., η_n – degrees of purification, respectively, in the 1st, 2nd and nth stages of the dust cleaning device.
2. Specific throughput, or specific air load, is the amount of air passing through a dust cleaning device per unit of time (usually within 1 hour), related to a certain characteristic value of the dust cleaning device (per 1 m2 ^{of} mesh or filter fabric).
Specific permeability m3 $^{/}$ (m2 ^{h} ·)

$$l = L / F$$

where L – the amount of air passing through the filter in 1 hour; F – filtering surface area^2.
3. Dust capacity is the largest amount of dust that can accumulate in a dust separator without causing a noticeable increase in its aerodynamic resistance. The time during which dust accumulates is determined by the moment the clean dust cleaning device starts working and the moment it stops for cleaning or regeneration of the filter material.
4. Aerodynamic resistance of a dust cleaning device is the difference in pressure (or vacuum) at the inlet and outlet of this device, Pa or N/ m^2.
The performance indicator of dust cleaning devices is also the specific energy consumption, kW-h , for cleaning 1000 m3 ^{of} dusty air.
The indicator characterizes the cost-effectiveness and efficiency of dust removal units operating under the same conditions.
For a more correct assessment of the operation of various dust collectors , it is necessary to take into account the area and volume of production facilities in which the devices are located. Within the enterprise, such an assessment of the operation of dust cleaning devices as the specific cost of air

purification should also be used - this is the sum of capital costs and operating costs for cleaning 1000 m3 of air.

Dust collectors are designed to clean ventilation (aspiration) emissions into the atmosphere if the concentration of dust in these emissions exceeds that permitted by sanitary standards.

In the specific case of cleaning air from fibrous dust in textile enterprises, we would classify (albeit somewhat conditionally) as dust-removal equipment, namely dust collectors, also fiber separators and fiber collectors, the main task of which is to separate fiber from air in pneumatic transport systems of fibrous materials and aspiration of textile machines. They are usually the first stage of air purification in the named systems.

Air filters are used to clean dust from outside and recirculated air supplied to the premises by supply ventilation and air conditioning systems.

Auxiliary equipment is necessary to complete the main dust removal equipment. This device is designed to remove captured dust or dust sludge from dust collectors, regenerate oil, etc.

According to the operating principle, dust removal devices can be divided into the following groups: gravitational, inertial , contact action, electrical, acoustic.

The operation of gravity dust collectors is based on the principle of using gravity forces, under the action of which dust particles settle. An example of a gravity dust collector is a dust settling chamber, called a dust cellar in textile factories.

Inertial dust collectors use inertial forces that arise when the direction of movement of the dusty air flow changes to separate dust particles from the air. Such devices include cyclones of various designs, etc.

In contact filters and dust collectors, dust particles are retained as a result of their contact with the surface of porous materials (fabrics, metal meshes, layers of granular materials, special foam). Separation of solid particles from air occurs during the passage of dusty air sequentially through numerous randomly located air channels (pores).

A distinction is also made between dry and wet dust collectors. IN DRY dust collectors, particles are not wetted and do not change their physical properties, so they can easily be used for further processing. In wet dust collectors, particles are wetted or stick to wet surfaces. In this case, their physical properties change.

The wet method of dust cleaning is used in some inertial and contact action dust collectors.

Conclusions. Dust collectors can be classified into three groups according to the degree of cleaning: coarse, medium and fine cleaning.

Electric dust collectors and filters remove dust from the air by electrifying the particles as they pass through an electric field. The charged particles move purposefully toward a surface with a charge of the opposite sign.

Table 3.9. Classification of dust collectors by their efficiency

Dust collector class	Dimensions are effective	Lower limits of efficiency depending on the dust dispersion	
	captured dust particles, µm	Dust dispersion groups	Efficiency, %
I	More than 0.3-0.5	V	80
		IV	99.9–80
II	More than 2	IV	92–85
		III	99.9–92
III	More than 4	III	99–80
		II	99.9–99
IV	More than 8	II	99.9–95
		I	99.9
V	More than 20	I	99

The operation of acoustic dust collectors is based on the effect of dust coagulation when a powerful acoustic field is applied to a dusty flow.
Coarse cleaning captures only coarse dust with a particle size of over 100 µm. Therefore, coarse cleaning dust collectors are used as the 1st stage. These devices are used at high initial dust concentrations in the air being cleaned. This includes all gravity and inertial dust collectors, single-stage electrostatic precipitators, acoustic dust collectors, mesh and some fabric filters, as well as most fiber collectors and fiber separators. Medium cleaning dust collectors include dust collectors and filters that ensure the retention of large and medium (over 10 µm) dust particles. The residual dust concentration during medium cleaning is 10–30 mg/m ^{3}.
Fine cleaning also captures fine dust, i.e. dust in which the fraction with a particle dispersion of less than 10 µm makes up more than 60%. The residual dust concentration during fine cleaning should be less than 2 mg/m3 · Such filters are used in supply ventilation and air conditioning units. They are suitable for operation in conditions of low dust concentration and small dust loads.
The classification of dust collectors and filters [6] is given in Tables 3.9–3.10.

Table 3. 10. Characteristics of types of dust collectors

Type of dust - collector	Dust collector type	collector efficiency class	The area of the most appropriate application according to dust dispersion groups					Resistance, Pa
			I	II	III	IV	V	
Gravitational	Dust settling chamber	V	+	+	-	-	-	$2 \cdot 10^2$
	High-performance cyclones (single and group) -	V	+	+	-	-	-	$2 \cdot 10^2$
	High efficiency cyclones	IV	-	+	+	-	-	$2 \cdot 10^8$
	Battery cyclones	IV	-	+	+	-	-	$2 \cdot 10^3$
Inertial	Centrifugal scrubbers and cyclones - washers	IV	-	+	+	-	-	$1 \cdot 10^3$
	Inkjet type	III	-	-	+	-	-	$1.2 \cdot 10^3$
	rotoclone	II	-	-	+	+	-	$3.4 \cdot 10^3$
	Venturi	III	-	-	+	-	-	$1.3 \cdot 10^3$
		II	-	-	+	+	-	$3.4 \cdot 10^3$
		III	-	-	-	+	+	10^3
Washers	Foamy	II	-	-	+	+	-	$2 \cdot 10^3$
	Mesh (for capturing fibrous dust)	V	+	-	-	-	-	$(4\text{-}8) \cdot 10^2$
Fabric	Fabric (sleeve)	III	+	-	-	-	-	$6 \cdot 10^2$
		II	-	-	+	+	-	$1.5 \cdot 10^3$
		1	-	-	+	+	+	$2.5 \cdot 10^3$
Electrical -	Electric plate	II	-	-	+	-	-	$3 \cdot 10^2$
		1	-	-	-	+	+	$6 \cdot 10^2$

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